United States
Department of
Agriculture

Forest Service

**Rocky Mountain
Forest and Range
Experiment Station**

Fort Collins,
Colorado 80526

**Resource Bulletin
RM-10**

Net Economic Value of Hunting Unique Species in Idaho: Bighorn Sheep, Mountain Goat, Moose, and Antelope

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Abstract

The net economic value of hunting unique species in Idaho was estimated using the Travel Cost Method. The net willingness to pay per hunting permit was $239 for bighorn sheep, $360 for mountain goat, $113 for moose, and $73 for antelope.

Acknowledgements

Dr. Louis Nelson of the Idaho Department of Fish and Game provided valuable input. Helpful comments were also received from Terry Raettig and James McDivitt of the USDA Forest Service; Nancy Green, Robert Milton, and Stan Frazier of the USDI Bureau of Land Management; Richard Walsh of Colorado State University; and Debbie Gibbs, formerly with the Bureau of Reclamation.

USDA Forest Service
Resource Bulletin RM-10

November 1985

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Management Implications

This bulletin describes efforts to improve information available to federal agencies with regard to valuation of antelope, bighorn sheep, moose, and mountain goat hunting in Idaho. For these unique species, only a very limited number of permits are issued; in Idaho these are allocated by a random lottery. Thus, the conventional Travel Cost Method had to be modified to give estimates of the net economic value per permit and per day of hunting of these four unique species in Idaho.

This study did not estimate the "total economic value" (Randall and Stoll 1983) because the option and existence values of these unique species were not measured. Existence value reflects the net willingness to pay by hunters and nonhunters for the opportunity to know that these unique species exist. Budget constraints at both the Idaho Department of Fish and Game and the cooperating Federal agencies precluded estimation of option and existence values. The work of Brookshire et al. (1983) served as the basis for speculations later in this bulletin on what the existence value per permit might be to maintain the opportunity to know bighorn sheep exist in Idaho. In addition Brookshire et al. (1983) will be used to consider the likely benefits of nonconsumptive use of bighorn sheep. In their article this is expressed as option price, which is the sum of expected recreation benefits and option value. Option value is the net willingness to pay to maintain the opportunity to observe bighorn sheep in the future given the possibility of irreversibly losing the species.

To compare hunting values, which recur every year, against commodity values that are extracted only once or over long intervals, a technique such as discounting is used. By using an interest rate (called the "discount" rate), annual returns and irregular returns can be converted to a lump sum in today's values, called a "present value" or present worth. The 4% discount rate used in National Forest planning was the rate used here to calculate the present value of a hundred year flow of hunting benefits for these four species. Higher discount rates such as used by the U.S. Water Resources Council would lower the present value. This resulting value conservatively assumes that the per permit value does not rise in real terms over time. In addition, the 1985 RPA Program (USDA Forest Service 1984), Dwyer et al. (1977), and U.S. Water Resources Council (1979, 1983) require that the fees paid be included along with the net willingness to pay. This is because the fee paid is nothing more than a transfer of benefits from the recreationists to the government. Combining present value of hunting with the net present value of other resource benefits compatible with preservation of the species, such as option and existence values, would allow comparison to the net present value of resource activities not compatible with wildlife preservation (at least in the case where this is an all or nothing choice).

Mountain Goat Hunting.—The estimated net economic value of a mountain goat hunting permit is $360 or $90 per hunter day. In a typical hunt unit offering 3 permits per year, the annual hunting value is $1,080. Calculating the present value of a hundred year flow of mountain goat hunting benefits for a hunt unit with three permits yields $27,000. Including just the resident fee for mountain goat hunting raises the net annual value of a permit to $431. This yields a net present value for hunting of $32,325 for the average herd unit providing three hunting permits.

Bighorn Sheep Hunting.—The estimated net value of a bighorn sheep hunting permit is $239 or $28 per day. The net present value of bighorn sheep hunting in a typical unit offering five permits is approximately $30,000 (based on an annual value of $1,195). Including the resident hunting fee yields a net present value of $39,000. A rough approximation of the likely annual observer option price and existence values in Idaho for bighorn sheep is discussed later in the report. These later calculations serve to illustrate the relationship of hunting values to other benefits of a unique wildlife species.

Moose Hunting.—The net estimated present value to resident moose hunters for current conditions in a typical moose hunting area offering an average of four permits valued at $112 each is $11,200. Including the resident hunting fee results in a net present value of $18,300 for maintaining current opportunities in a typical moose hunting area. The value per day is $19.12. These moose hunting values are underestimates because of the effect the Idaho Department of Fish and Game's in-state-hunter-only rule has on the Travel Cost Method of estimating values.

Antelope Hunting.—The net present value to antelope hunters from maintaining a typical area offering 90 permits valued at the state average of $73 per permit is $165,950. Including the resident fee as part of the net benefit to society results in a net present value of $234,000 to hunters. The net economic value per hunter day is $38.58.

Managers are cautioned that site-specific values for individual hunt units are often more appropriate for project analyses than these state averages. Because of the reliance on a lottery to ration the few available permits among the many applicants, these site average values per permit also represent the marginal value of an additional permit (Mumy and Hanke 1975). This equivalence of marginal and average values will be discussed in detail later in this bulletin.

In all of these values the reader must keep in mind that this is the value for just two to three weeks of use of the species by hunters. If estimates of the option and existence values as well as nonconsumptive use values were added, this figure could easily be twice as large (Walsh et al. 1984). However, even the hunting values given here do provide a minimum value which can be compared to alternative uses of the habitat.

There are two benefits resulting from management that increases the populations of these animals. The most immediate effect is that success rate rises, and because success is a variable in our demand equations, willingness to pay of existing hunters rises. In the long run, higher animal populations allow for offering more permits to accommodate more hunters.

Introduction

The net economic values of antelope, bighorn sheep, moose, and mountain goat hunting have never been estimated in Idaho using the Travel Cost Method. Thus, the first objective of this research study was to quantify the net economic values of hunting these four unique species in Idaho, and to make this information available to the Idaho Department of Fish and Game, the Bureau of Land Management, USDA Forest Service, and conservation organizations. Inadequacy of previous simple Travel Cost Method approaches is one possible reason no one has previously quantified the net economic value of hunting these species in Idaho. Specifically, the simple Travel Cost Method will not work for these limited hunt species because of excess demand for permits at the current fee and travel cost. Based on the work of Loomis (1983) in Utah, the Travel Cost Method must be modified so it can be used with data from applications instead of actual trips taken. However, the permit applications in Utah were for a single site. No one has attempted to generalize the approach to a Regional Travel Cost Method, e.g., a multi-site system. Thus, a second research objective was to generalize the single-site Travel Cost Method adjustment and apply it to Idaho. By evaluating multiple sites it becomes possible to investigate the extent to which differences in site quality affect the demand for hunting these unique species.

Given the ability to evaluate quality, a third research objective was to statistically test how quality enters the Travel Cost Model. Traditionally, quality has entered as a demand shifter. Recent work by Vaughan and Russell (1982) suggests that quality also might enter as a slope shifter on the price variable. The same authors found that quality did enter as a slope variable as well as a shifter with regard to fishing. This paper will attempt to determine if the same result holds for activities such as mountain goat hunting.

The fourth major research objective relates to evaluation of these four species as part of the Idaho "prototype" study which is designed to test the cost effectiveness of combining state data with federally approved methods such as the Travel Cost Method to estimate the net economic values required by the 1990 Resources Planning Act (RPA) effort.

Methodology

Definition of Economic Value

For the purposes of Benefit Cost Analysis, Forest Planning Optimization (USFS FORPLAN), and Range-Wildlife Investments (BLM's SAGERAM), economic values for all outputs are defined in terms of net willingness to pay by the user. This is the correct value of forage to ranchers, the value of water to farmers and the value of wildlife to hunters. Net willingness to pay is the standard measure of value in benefit cost analyses performed by the U.S. Army Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service (U.S. Water Resources Council 1979, 1983). Net willingness to pay is the intended foundation of the Forest Service's RPA values. The Rangeland Investment Policy of the Bureau of Land Management stipulates willingness to pay as the value of all outputs in a SAGERAM analysis (BLM 1982).

User's gross willingness to pay is made up of two components. The first is the actual expenditure paid to engage in some activity (e.g., farming, ranching, or hunting). Expenditures are a cost to the user and are not appropriate for valuation of wildlife or any other resource (Knetsch and Davis 1966). Expenditures are primarily useful for measuring the effect or impact of some management action on local economies.

The second component of gross willingness to pay is known as "economic surplus." If there is a benefit remaining after all costs are paid then there is an economic surplus realized by the producer or consumers. Economists call the surplus accruing to producers "producer surplus" and the surplus accruing to consumers "consumer surplus." It is the change in producer or consumer surplus resulting from some management action that is the benefit or net economic value of that action. In the case of hunting, the surplus that is generated by maintaining population of the unique species is generally regarded as a consumer's surplus (Burt and Brewer 1971). In this report the term consumer surplus and net willingness to pay will be used interchangeably.

Travel Cost Method of Estimating Value

Dwyer et al. (1977), U.S. Water Resources Council (1979, 1983), Walsh (1983), and Knetsch and Davis (1966) all recommend the Travel Cost Method (TCM) as one of the two most commonly used, yet conceptually

correct, methods for valuing recreation. The traditional Travel Cost Method relies on variations in travel costs of recreationists to trace out a demand curve; that is, the number of trips taken and the associated travel costs are taken as observations of equilibrium price-quantity points along a demand curve. Once the demand curve is estimated, the area above the expenditure but under the demand curve provides a measure of net willingness to pay (consumer surplus) for continued existence of that site. For the reader unfamiliar with the Travel Cost Method see Dwyer et al. (1977) or Clawson and Knetsch (1966).

One of the assumptions required by the traditional Travel Cost Method is that everyone wishing to enter the site at the current travel cost (price) is allowed to (Dwyer et al. 1977). This means there is no excess demand or no capacity constraint denying access to recreationists desiring to visit the site for a specific activity. In the case of hunting permits for bighorn sheep, antelope, moose, and mountain goat in Idaho this assumption is invalid. There are 10 to 100 applications for each permit, and only those hunters who have their applications selected by a random lottery actually may hunt at the site. As shown in Loomis (1983), actual visits do not serve as a measure of demand under these conditions. The correct measure of demand is the number of trips hunters would like to make at the current fee and travel cost, as given by the number of applications at each travel cost, i.e., the true price-quantity equilibrium.

Once the demand curve is estimated using applications, the long-run value (i.e., expected value of the lottery) of a permit can be arrived at. Use of the expected value or average value of a permit is consistent with the suggestion of Mumy and Hanke (1975) that when non-price rationing is used, marginal values equal average values because, without pricing (and particularly with a lottery), the ordering of consumers in terms of highest to lowest willingness to pay is destroyed. Only with pricing does the value of the next unit have a value lower than the previous one. For only with pricing are we assured users with the highest willingness to pay receive a good before users with lower willingness to pay (hereafter called "high valued user" and "low valued user"). Without pricing or with a random rationing system, the next unit could go to either a high or low valued user. Hence, the value of an additional unit should be calculated as an expected value of the probabilities of high and low valued users receiving the next unit. With a random assignment system, this turns out to be the average consumer surplus.

In this study a Regional (multi-site) Travel Cost Model was constructed. The dependent variable is applications per capita (instead of the traditional trips per capita). The "per capita" specification is used to adjust for differences in population sizes of counties of hunter origin. As Brown et al. (1983) have shown, the per capita specification takes into account not only the number of visits as a function of distance, but also the probability of visiting a given site (here, applying for a permit) as a function of distance.

The possible list of independent variables include hunt site quality variables such as harvest success and scenic value, measures of substitutes (if there are any), demographic characteristics of hunters, and a price variable. Because the analysis relied primarily on information that could be obtained from the hunter application form, a relatively simple Regional Travel Cost Model was estimated. The basic model was as follows:

$$A_{ij}/POP_i = B_o - B_1DIST_{ij} + B_2SUCES_j - B_3SUBS_i + B_4INC_i + B_5NPERMT_j \qquad [1]$$

where A_{ij} = applications from origin i for hunting in site j

POP_i = population of origin i

$DIST_{ij}$ = distance from origin i to site j

$SUCES_j$ = harvest or success rate at site j

$SUBS_i$ = substitute sites available to origin i

INC_i = per capita income of origin i

$NPERMT_j$ = probability of receiving a permit for site j (i.e., here, number of permits offered)

$B_o - B_5$ = coefficients to be estimated.

Equation [1] specifies a per capita demand curve for hunting sites in Idaho. Equation [1] states that the number of applications per capita from origin i to site j is a function of the distance from origin i to site j, quality of site j, the substitute sites available to origin i, the per capita income of residents in origin i, and the probability of obtaining a permit. By setting the quality or harvest measure at a value associated with a specific site, the Regional Travel Cost demand curve becomes the demand curve for the specific site. Thus, with one equation the researcher can model recreation use and benefits at all of the hunting areas for a particular species.

From the per capita demand curve, a second-stage demand curve is derived that plots total trips (here applications) to a site as a function of hypothetical added distance. Once the added distance is converted to dollars, the area under this second-stage demand curve represents net willingness to pay for the site under consideration. It is net willingness to pay because only the added distance or cost is reflected in the second-stage demand curve, not the original cost. The reader unfamiliar with this two stage process is encouraged to see Clawson and Knetsch (1966) or Dwyer et al. (1977). Lastly, the total site net economic value (net willingness to pay) can be converted to a net economic value per permit by dividing the estimated site net value by the number of applications received for that unit.

One advantage of statistical approaches to benefit estimation is that both a point estimate and the associated range of likely values can be derived. This range helps to establish a high and low boundary around the point estimated. This boundary conveys information to the decisionmaker about the accuracy of the point estimate. If a resource allocation decision remains unchanged as long as the value per day remains within this interval, then no more data need be collected for this species.

The traditional statistical range or interval, called "confidence interval," is a numerical range that encloses (with a certain probability, often 95% or 99%) the true parameter. Because empirical estimates of net

willingness to pay (consumer surplus) are most sensitive to the price coefficient (here distance), the 95% confidence interval values of the distance coefficient were chosen to calculate the range of the per permit hunting values. This accounts only for the uncertainty surrounding the price (slope) coefficient and does not consider uncertainty surrounding estimates of the other slope coefficients nor the intercept term. For equations that use a linear functional form, the true confidence intervals around the benefit estimates are larger than our simple confidence intervals indicate. For the remainder of the report we will refer to these "price slope only" 95% confidence intervals as "sensitivity intervals." This term is used to describe the range in benefit estimates resulting from varying the distance coefficient from its lower 95% confidence value to its upper 95% confidence value. For the demand curves that use natural log of applications per capita, the appendix shows the average consumer surplus per permit is equal to the reciprocal of the price coefficient. For this functional form, our "price slopes only" confidence intervals are true statistical confidence intervals for average consumer surplus per permit.

Once identification of candidate variables has been accomplished, the issue of functional form and ordinary versus generalized least squares must be addressed. Based on past experience and several recent journal articles dealing with these issues, two basic model structures were considered:

$$\ln(A/POP) = B_o - B_1 DIST + B_2 SUCES - B_3 SUBS + B_4 INC + B_5 NPERMT \qquad [2]$$

$$(A/POP)(\sqrt{POP}) = B_o(\sqrt{POP}) - B_1[(\ln DIST)\sqrt{POP}] + B_2 SUCES(\sqrt{POP}) - B_3 SUBS(\sqrt{POP}) + B_4 INC(\sqrt{POP}) + B_5 NPERMT(\sqrt{POP}) \qquad [3]$$

where A = application
DIST = round-trip distance
SUCES = hunter success rate in percent
SUBS = substitute index (for antelope only)
INC = county per capita income
NPERMT = number of permits
POP = county population.

Equation [2] adopts a functional form that several economists have argued is most plausible. Ziemer et al. (1980), Vaughan et al. (1982), and Strong (1983) argue that because of the pattern by which trips per capita falls off at higher distances, the natural log of visits per capita is preferred to a simple linear form or even natural log of distance. Their point is that with either of these latter functional forms, negative visits are sometimes predicted for a few distant origins. These authors feel negative visits are counterintuitive, and this fact provides one factor supporting the log of visits (application in this study) per capita.

Bowes and Loomis (1980) argue the unequal sizes of population zones requires a square root of zone population weight to each variable to correct for the inherent heteroskedasticity of zonal TCM's. This weighting scheme corrects for heteroskedasticity and is equivalent to generalized least squares. The use of generalized least squares in this situation insures exact prediction of the total applications and less variance in the benefit estimates (Bowes and Loomis 1980). However, Vaughan and Russell (1982) and Strong (1983) show that if the log of visits per capita is chosen as the functional form, the heteroskedasticity may be so greatly reduced (but not eliminated) that weighting by square root of population may be unnecessary.

The choice of functional form and whether to use generalized or ordinary least squares is quite dependent on the data set one is analyzing. No one functional form is best for all data sets. The data will often inform the researcher as to which functional form is consistent with the behavior underlying the data. Whether the log functional form reduces heteroskedasticity sufficiently can be determined by comparing the estimated applications (from the equation) against the actual number of applications in the sample. If estimated applications are within 20% to 30% of actual applications, this may be acceptable if the researcher's primary interest is with benefit estimation. If estimated applications is greater than, say, 30% variance with actual applications or if use estimation is the primary interest of the researcher, then the generalized least squares approach, using weights suggested by Bowes and Loomis (1980), would be appropriate. Benefit estimation was the primary purpose of this study, and the functional form giving the smallest standard error on the distance variable (the one crucial to benefit estimation) will be chosen as long as the estimated applications is within 30% of actual applications. Otherwise the generalized least squares will be relied on. The choice will be discussed species by species in the results section.

Statistical Analysis

Data Sources and Data Compilation

The data necessary for travel cost modeling consist of applications (potential trips), distance, income, a measure of the probability of obtaining a permit, a substitute measure, and a quality measure. The data on number of potential trips from each county to each site were obtained from the limited hunt application form. On this form the hunter must state his or her address and herd unit desired. Thus, the origin-destination information was obtained without surveys. Per capita income was obtained from secondary Federal Government sources (Bureau of Census 1982). As a first approximation of quality, the percentage success rate in the unit was used. The probability of receiving a permit was taken as a direct function of the number of permits offered.

The distance from each origin to each site was calculated by the State of Idaho Department of Fish and Game. The Department used maps and their knowledge of travel routes to each herd unit to calculate the round-trip distance to each unit for each origin.

The data represent an entire census of limited hunt species applicants rather than a sample; i.e., all of the persons applying for a permit for a given species are in-

cluded. This is necessary so that the true demand curve can be estimated. If the demand curve was just estimated on hunters receiving a permit, the true price and quantity relationship would be distorted by the random drawing or lottery. Loomis (1983) has shown that the distortions can be large. By estimating the demand curve reflecting what hunters would like to purchase at the current license fees and travel cost, this lottery-induced distortion is avoided and the efficiency of estimation improved.

For mountain goat, antelope, and bighorn sheep hunting the data reflect applications from hunters all over the country. Several applications were received from states on the west coast as well as the east coast. It is important to include these observations (assuming, as is likely for these species, that the trips would be primarily to visit the site applied for and to hunt the species applied for) because the variation in willingness to travel is used to infer a willingness to pay when utilizing the Travel Cost Method of estimating the demand curve. The definition of an origin or place of residence was expanded to include entire states or groups of states so that these observations could be included without having to add adjacent counties or states as separate zero observations.

In the case of moose hunting, Idaho state regulations prohibit out of state hunters from applying for a moose hunting permit, and therefore the data for moose hunting are limited to just in-state residents. This is likely to seriously bias the Travel Cost Method derived benefit estimates for moose hunting because the assumption is that all persons wishing to make a trip (here, applications) at every given distance are included in the sample (Dwyer et al. 1977). But, the in-state only rule eliminates from the sample hunters who would likely be willing to travel great distance for the opportunity to hunt moose in a wilderness setting provided in Idaho. Since the Travel Cost Method uses willingness to travel to infer willingness to pay, this in-state only rule will result in an underestimate of the additional willingness to pay by hunters living in Idaho. This underestimate is a direct result of the data incorrectly showing that no one is willing to travel from beyond the state boundary to visit these moose hunting sites. While there are sophisticated statistical routines to deal with truncated samples, they are difficult and expensive to use. Study constraints precluded any attempt to reestimate the demand curves using these special regression techniques. Therefore, it was decided to estimate the moose hunting equations knowing ahead of time they would be underestimates rather than estimate no value at all for moose hunting.

As explained below, a variable reflecting availability of substitute sites was seriously considered only for antelope hunting. The calculation of a substitute site variable utilized information on both quality of substitutes sites and distance (price) as to the substitute site. Quality was represented by hunting success in the unit. While other factors influence the desirability of an area, this was the primary variable on which information was available for all units at minimum computational costs. This quality measure was also used as a measure of attractiveness of substitute hunting sites. The form of the substitute index will be discussed in the Interpretation of Results section.

Based on discussion with an Idaho State Fish and Game biologist, it was determined that no substitute sites were available in Idaho for bighorn sheep hunting, moose hunting, or mountain goat hunting.[4] This seems to be a reasonable assumption for resident hunters since often times these species are not available in adjacent states. If the species is present many times few if any permits are allocated to nonresidents and even when permits are available, the nonresident permit fee (and travel distance) make adjacent states a very poor substitute. The lottery situation clearly indicates that there are no substitute sites within Idaho that can accommodate hunters interested in switching sites. In addition, substitutes are often used to find the added distance at which the hunters would switch to a substitute site. In the case of bighorn sheep, mountain goat, and moose, a hunter could not switch areas if the price got too high but would rather just go back into the pool of applicants for another site. It is unlikely that a hunter, after waiting several years to obtain a permit for one of these three species, would give up a certain permit and go back into a pool of applicants at the added prices for the next site (about $100–$200). For antelope, the proximity to Wyoming (with available nonresident permits) and the limited amount of excess demand (8,795 applicants for 2,435 permits, far less than for the other three species) makes substitutes more plausible.

County per capita income was also tested as a variable since economic theory indicates that it should influence purchases of trips to a recreation site. Hunter's income would have been preferable, but without a survey, that information was not available. Thus, a negative sign on the income variable is possible since per capita incomes on the west and east coasts were significantly higher than in Idaho. Due to the dominant effect of distance in reducing visits as one moves further away from the site, income and visits may be negatively correlated. This does not mean that as a given hunter's income rises he would not hunt more. The negative relationship may just be an artifact of income rising as distance from the site increases. Nonetheless, it was felt that income, when significant, should be included in the per capita demand curves.

Calculation of TCM Benefits

To calculate benefits from the second-stage demand curve with added distance as the price variable, the researcher must convert distance to dollars. Travel costs to a site consist of transportation costs and travel time costs. Travel time is included because, other things remaining equal, the longer it takes the hunter to get to a site, the fewer visits will be made. Thus time, because it is a limiting factor, acts as a deterrent to visiting more distant sites. Omission of travel time will bias the benefit estimates downward (Cesario and Knetsch 1970,

[4]*Personal communication with Louis J. Nelson, Staff Biologist, Idaho Department of Fish and Game.*

Wilman 1980). The U.S. Water Resources Council (1979, 1983) requires consideration of the effect of travel time in doing TCM studies. It is worth noting the Federal Highway Administration (1984) routinely includes the travel time saved as a benefit for improving highways much like recreation economists would of introducing a new site closer to recreationists. This is simply recognition that time is a resource that has an opportunity cost and saving time provides an economic efficiency benefit no different than saving gasoline.

The value of time was set at one-third of the wage rate as recommended by the U.S. Water Resources Council (1979, 1983). This is the mid-point of values of travel time that Cesario (1976) found in his review of the transportation planning literature. It must be kept in mind that the use of one-third the wage rate is not intended to measure the wages actually foregone during the time spent traveling, but rather the deterrent effect of scarce time on visiting more distant sites. This study used the U.S. Department of Labor's estimate of median wage rate in 1982 of $8.00 an hour. One-third of this amount is $2.67 per hour. On average, this yields about $0.066 per mile. This value per hour is about two-thirds the value used by the Federal Highway Administration (1984) in its highway studies. Without a survey, this approach of using average wage rates must suffice. While income of bighorn sheep or mountain goat hunters is likely above average, using a national average wage rate probably compensated for this. That is, since the national average wage rate is above wage rates found in Idaho, eastern Washington, and Oregon (where a large majority of the applications came from), the underestimate of the benefits due to travel time costs is probably not significant.

Evaluation of the transportation component of travel cost was more straightforward. The U.S. Water Resource Council suggests that variable vehicle costs be calculated from the U.S. Department of Transportation's "Cost of Owning and Operating a Motor Vehicle." Because there is no category for pickup trucks or four-wheel-drive vehicles, an intermediate size car was chosen as the best proxy to calculate what is termed in this report "standard" cost. For 1982 its variable cost was $0.135 per mile. Variable costs are used since we are interested in the incremental cost paid for this trip and by definition fixed costs are invariant to a decision of whether to take a trip or not.

It is likely that the cost per mile from this source may be an underestimate of the cost for such a highly specialized activity as big game hunting. Without survey data for bighorn sheep hunters, mountain goat hunters, and moose hunters, it was assumed that an approximation of the true cost of transportation to hunt these species might be the cost per mile reported by elk hunters. The reported cost per mile of deer hunting was taken as an approximation to the cost per mile of antelope hunting. These assumptions were discussed with Idaho Department of Fish and Game personnel to verify the reasonableness of such assumptions.[4] In this bulletin, the use of reported cost of elk hunters or deer hunters will be called "reported" cost. The reported cost per mile is generally higher because it reflects the operating cost of vehicles commonly used in big game hunting. In addition, the costs reflect the actual road conditions associated with big game hunting rather than "suburban" driving conditions associated with the Department of Transportation's estimates of costs per mile. The reported cost per mile for elk hunting is $0.31 per mile.[5] The cost per mile for deer hunting is $0.183 per mile.[6] The effect of using a higher reported cost per mile is to associate each quantity consumed with a higher price than if a lower standard cost per mile is used. If the cost per mile is higher, the "implied willingness to pay" at the margin for the last trip (as based on distance driven) is greater. This has the effect of an upward shift in the demand curve at every quantity. Thus, the net willingness to pay will be correspondingly higher. Estimates of net willingness to pay per permit will be displayed with both standard cost and reported cost to allow comparisons to other studies that may have used standard cost.

For hunting these species where acquisition of a permit is by lottery, the number of licensed hunters per vehicle is likely to be just one, especially for moose, bighorn sheep, and mountain goat where 3 to 10 permits is the common number per unit. Thus, the vehicle transportation costs are assumed to be borne completely by the single licensed hunter.

Once the transportation cost per mile and the value of travel time per mile is known, distance can be converted to dollars. When using a second-stage demand curve approach to calculating benefits, the added miles are then converted to price over and above costs using the sum of transportation costs and travel time. This rescales the vertical axis of the second-stage demand curve for each site from added distance to added dollars. The area under the second-stage demand curve reflects the net willingness to pay for the site in question. A separate second-stage demand curve is estimated for each site.

From this second-stage demand curve an average net willingness to pay for each permit can be calculated by dividing the total net willingness to pay by the number of applications. Since only a few of the many hundreds of applicants actually receive a permit, this average value is then multiplied by the actual number of permits offered in this area to get the net willingness to pay in a typical year. While Loomis (1982) shows that one could calculate the actual net willingness to pay associated with any outcome of the lottery, it is argued that this value may not reflect the long term average when only a few permits are drawn. The long-term value is better reflected in the expected value of the permit, which is equivalent under a random lottery to the average value of a permit.

Once this net willingness to pay or consumer surplus is calculated, it is necessary to add the hunting permit fee paid to obtain an estimate of the economic efficiency benefits to society from providing this opportunity (USDA Forest Service 1984; Dwyer et al. 1977; U.S. Water Resources Council 1979, 1983). The permit fee

[5] *Cindy Sorg, Net Economic Value of Elk Hunting in Idaho. Manuscript in preparation, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.*

[6] *Dennis Donnelly. Net Economic Value of Deer Hunting in Idaho. Manuscript in preparation. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.*

merely reflects a transfer of consumer surplus from the hunter to the government. No significant real resource costs are involved, merely a change in property rights. Had the hunter been able to obtain the permit without cost, he or she would have received just that much more consumer surplus. Having added the dollar amount of the hunting license to the net value per day, it is also important in benefit cost analysis to include the additional costs to both the federal, private, and state agencies in computing costs of some wildlife management action.

Estimated Demand Equations

The estimated regression equations provide statistically significant per capita demand curves for all four species. For all of these species, the process of testing significance of variables, choice of functional form, and choice of generalized versus ordinary least squares was the same. The model presented in equations [2] and [3], which contained all of the variables that theory indicates should be considered, were run using SPSS statistical package. Variables found to be insignificant or highly correlated to distance (such that multicollinearity was a problem) were dropped from subsequent runs. Even though theory indicated an *a priori* expectation of importance, the generality of consumer utility theory as applied to the Travel Cost Method could not be relied on to specify the form in which the variable entered. To see if candidate explanatory variables entered in a nonlinear fashion, the variable and the square of that variable were tried, as was the natural log of that variable.

The final parameters were estimated after removal of insignificant variables. The resulting equation was then checked for its capability to predict applications. Estimated applications (summed across sites) was compared to the actual number of applications in the data set. It was at this point that choice between functional form and generalized and ordinary least squares became apparent. For mountain goat hunting, the natural log of applications per capita was unable to significantly reduce the inherent heteroskedasticity of the unequal origin populations. This natural log of application per capita equations misestimated applications by 50%. The generalized least square model using natural log of distance estimated applications to within one of the actual number in the data set. Based on the substantial error in the ordinary least squares equation of applications per capita, the weighted regressions are used to calculate benefits for mountain goat. The natural log of visits per capita (ordinary least squares model) performed better than the generalized least squares model in estimating an equation for bighorn sheep hunting, antelope, and moose hunting.

Mountain Goat Hunting.—The mountain goat hunting demand equation is:

$$\begin{array}{lll} (A/POP) = & 0.0000938 & - 0.0000114[\ln(DIST)] \\ \text{T values} & (2.989) & (-2.90) \end{array}$$

The F ratio for this equation is 4.74, where variables are the same as defined earlier in equations [2] and [3], which indicates the overall equation is statistically significant at the 95% level. The distance coefficient is significant at the 99% level. The R^2 is not reported because its calculation assumes ordinary least squares estimation (more specifically, a column of 1's for the constant term) whereas this equation was estimated with generalized least squares to obtain an accurate use estimate. Generalized least squares was used because use of ordinary least squares with the natural log functional form did not adequately solve the inherent heteroskedasticity of the zonal data, and thus the ordinary least squares grossly mispredicted use. In addition, the natural log of visits per capita form did not result in any variables other than distance being significant (at similar levels of statistical significance) but the generalized least squares predicted far better. Therefore, the generalized least squares equation was selected for benefit estimation. It should be noted this equation does predict estimated trips equal to actual trips. Therefore, it does seem to represent the data fairly well, although it is disappointing that success, income, or number of permits were statistically insignificant. Several forms of the success variable were tried. The suggestion by Vaughan and Russell (1982) that success might act as an intercept and slope dummy was tried, but did not result in success being significant in combination (slope and intercept) or in the slope form only. Time did not permit testing the slope dummy on other species.

Moose Hunting.—The moose hunting demand equation estimates for residents is

$$\begin{array}{ll} \ln(A/POP) = -7.92 - \underset{(-12.9)}{0.0032DIST} + \underset{(2.03)}{0.033\ SUCES} \\ \qquad - \underset{(-1.788)}{0.0002(SUCES)^2} + \underset{(6.79)}{0.0297NPERMT} \end{array}$$

The R^2 is 0.42 and the F ratio is 57.07. Here, the R^2 is the percentage variation in the log of applications per capita explained by the independent variables. The F ratio indicates the overall equation is significant at the 99% level. The distance and number of permit coefficients are significant at the 99% level. The success and success-squared variables are significant at the 95% and 90% level, respectively. The moose hunting per capita demand equation using the natural log functional form estimated applications within 25% of actual applications. While this may not be precise enough if one's goal is use forecasting, our main goal is benefit estimation. As such the natural log functional form yielded a substantially smaller standard error on distance and a significantly higher F value. Therefore, it was used in the next section to calculate benefits.

Bighorn Sheep Hunting.—The per capita or first-stage demand curve for bighorn sheep permit is:

$$\begin{array}{lll} \ln(A/POP) = -5.688 & - 0.00141DIST & + 0.01149SUCES \\ \text{T values} & (-15.19) & (1.966) \\ & + 0.0195NPERMT & - .0006INC \\ & (1.835 & (-6.86) \end{array}$$

The R^2 is 0.63 and the F ratio is 117.87. Here, R^2 is the percentage variation in the log of applications per

capita explained by the independent variables. The F ratio indicates the overall equation is statistically significant at the 99% level of confidence. All variables other than number of permits are significant at the 95% level, while number of permits is significant at the 90% level. It is worth noting that the large T value on the distance coefficient (a result of the very small standard error on the distance coefficient) will translate into a benefit estimate with a very small variance. The negative sign on income results from the fact that as one moves further away from the bighorn sheep hunting sites (and in Idaho in general) county per capita income goes up. In future studies it may be desirable to use actual hunter income to see if this problem is avoided. For bighorn sheep hunting there was enough variation in success rate and number of permits that applications seem to be sufficiently sensitive to these variables. The bighorn sheep equation using the natural logs was a little disappointing in terms of use prediction capability. The equation predicted about a third more applications than were received. If use estimation was the primary concern, this degree of error might be of concern. In this case, use estimation is a minor concern because there is so much excess demand for a permit that any additional permits provided would be taken. The natural log functional form had a substantially smaller standard error on distance than the generalized least squares. For precision in benefit estimation the standard error on distance is of prime importance. In addition, the F value for the natural log equation was significantly higher than the F for the generalized least squares. Therefore, the natural log functional form was used to calculate benefits.

Antelope Hunting.—The antelope hunting TCM equation is:

$$
\begin{aligned}
\ln(A/POP) = & -6.2889816 - \underset{(-22.23)}{0.0032258DIST} \\
& + \underset{(4.055)}{0.019658SUCES} + \underset{(5.498)}{0.003285NPERMT} \\
& - \underset{(-2.34)}{0.0925SUBS} - \underset{(-5.545)}{0.0003759INC}
\end{aligned}
$$

T values shown in parentheses below each coefficient.

The overall equation is quite significant as judged by an F value of 186.2, which is significant well beyond the 99% level. The R^2 is 0.66, which is fairly high for cross-section regression. However, it must be emphasized this is the percentage of the explained variation in log of applications per capita rather than the percentage of variation in untransformed applications per capita on applications. The R^2 on actual applications is likely to be lower. This equation has a very small standard error on distance, which will translate into a tight 95% sensitivity interval on the benefit estimate. This equation has substitutes, quality, and number of permits as statistically significant variables exhibiting the theoretically correct sign. The unexpected negative sign on income is explained by the fact that the further one gets from rural Idaho the higher per capita income usually is.

A similar equation was estimated for antelope that used harvest and harvest divided by distance as the quality and substitute variable, respectively. This equation had a similar F value, R^2, and t statistics, but the sign on number of permits was negative.

In terms of accuracy of use estimation, the inclusion of the substitute term greatly improved the match between estimated and actual permits demanded. The number of actual applications was 8,795 and estimated number was 6,566. The estimated use is within 75% of the actual use level. While this may be too low if one's goal is solely use estimation, it is reasonably good for the purposes of benefit estimation. In addition, the use of generalized least squares to estimate the antelope regression did not result in the substitute variable having the theoretically correct sign. The incorrect sign on the substitute variable may result in overestimation of benefits. Avoiding overestimation of benefits was more important than improving use estimation.

This effect of inclusion of the substitute variable on benefit estimates will be discussed in the next section. Here we wish to briefly explain the construction of the substitute variables used in the antelope regression. This substitute term is modelled after Knetsch et al.'s (1976) measure. Their substitute term had attractiveness of the substitute site in the numerator and distance to the substitute site in the denominator. In our study attractiveness was related to success rate or harvest. Any site (k) was considered as substitute for site j if the ratio of success to distance from origin i to site k was greater for site k than site j's ratio. That is, site k would be a cost-effective substitute because it had a higher harvest per mile driven than the site under study (j). Therefore, both quality and cost (distance) of alternative sites were considered in determination of what sites were substitutes for others. The actual substitute measure was the sum of the indexes for all sites having a higher harvest or success rate per mile than the site under study. Because our research effort was generally limited to existing data, only sites applied for by at least one hunter from a given origin (county or county-state group) were considered as potential substitutes. This is a narrowing of the range of alternatives from that used by Knetsch et al. (1976). Study time limits did not allow for evaluating all possible substitutes. In addition, household production theory (Mendelsohn and Brown 1983) would suggest that only sites actually visited from an origin are efficient or on the "characteristic frontier" for that origin. Sites not visited from that origin may not be cost effective.

Benefit Estimates

The per capita or first-stage demand curves can be directly integrated by origin (below the demand curve but above the distance) to yield the total net willingness to pay (consumer surplus) for each site. Once the total is known, the average value per permit is easily calculated by dividing the total by number of applications. Alternatively, the per capita demand curve can be used to estimate a second-stage demand curve, the area under this is the total consumer surplus. This second-stage de-

mand curve approach was adopted in this study. As Burt and Brewer (1971) showed, the two approaches yield identical results (other than rounding).

The first step in constructing the second-stage demand curve is to use the per capita demand curve to estimate the change in applications from each origin as distance is increased above the actual distance. This process is repeated by adding greater and greater distances (and recording the resulting applications) until applications from a given origin drop below one. Note that each site has its own unique second-stage demand curve as the number of applications, quality, and distance to the site are specific to each site. Thus, from one per capita demand curve the analyst can obtain unique second-stage demand curves for each of the sites by just setting the value of each of the independent variables at the level associated with the site of interest.

The second step in constructing the second-stage demand curve is to convert added distance to dollars. This conversion rescales the vertical axis of the demand curve to dollars. This conversion is made using the sum of transportation cost and value of travel time. As discussed earlier, the transportation cost was calculated using the "standard" cost from U.S. Department of Transportation and the "reported" cost from elk or deer hunting surveys in Idaho. The benefit estimates are higher when distance is converted to dollars using the higher reported cost rather than the standard cost because when reported cost is used each quantity of applications from each origin is associated with a higher gross willingness to pay (at the margin). The standard cost figure is reported as a benchmark to allow comparison to other studies and because the U.S. Water Resources Council suggests that this standard cost figure be used. However, for specialized activities where four-wheel-drive vehicles and camper-trailers are not uncommon, the reported cost figure is probably a more accurate reflection of gross willingness to pay.

Mountain Goat Hunting.—When distance is converted to dollars using standard cost per mile, the state average net willingness to pay for a permit is $193 (table 1). With an average of 4 days hunted per permit (according to the Idaho Department of Fish and Game[4]), this translates into $48 per day. Depending on the length of a hunting day, this could mean $70 to $90 per 12-hour Recreation Visitor Day (RVD). When distance is converted to dollars using the "reported cost" figure associated with elk hunting ($0.31 per mile), the net willingness to pay per permit is $360 (table 1), and the average value per day is $90.

These figures are net willingness to pay over and above all costs. Adding the resident permit fee of $71 for mountain goat hunting into the net willingness to pay per permit at reported cost yields $431. This raises the average value of a day to $108. This is the value to hunters only for hunting; it excludes nonhunting benefits such as observation or existence values. Even so, the net present value of maintaining mountain goat hunting in a typical management unit offering three permits is still $32,325 at 4% interest. At higher discount rates, the net present value would be lower.

These state average mountain goat hunting values are summarized in table 1 along with the state average values for other species. Because each herd unit has its own second-stage demand curve, each site will have its own unique total and average consumer surplus. Table 2 presents the average consumer surplus per permit for each of the mountain goat hunting areas. For evaluation of a specific project, the value of that specific site should be used to estimate benefits of an additional permit rather than the state average value.

Moose Hunting.—The benefit estimates for moose hunting were very conservative since the willingness to travel (i.e., willingness to pay) of nonresident hunters was excluded by the in-state only requirement for moose hunting applications. The state average net value per permit is $60 at standard cost. At the reported cost associated with elk hunting ($0.31 per mile), the net willingness to pay for a permit is $112.84. The 95% sensitivity interval around this $112.84 permit value is $97 to $133. A rough approximation of the impact of limiting moose hunting permits to resident hunters may be seen by comparing this benefit estimate to the net value of a mountain goat hunting permit. Excluding nonresidents could have the effect of reducing the estimated net willingness to pay by two-thirds. The per day net willingness to pay value (at reported cost) of a moose hunting permit is $19.12 based on an average of 5.9 days hunted per per-

Table 1.—Summary of Idaho average values per hunting permit and per day (not including license fees).

	Species			
	Bighorn sheep	Mountain goat	Moose	Antelope
Average days per permit	8.6	4	5.9	1.9
Standard cost				
Permit	$127.54	$193	$ 60.43	$59.21
Day	$ 14.83	$ 48	$ 10.24	$31.16
Reported cost				
Permit	$239.00	$360	$112.84	$73.31
Day	$ 27.80	$ 90	$ 19.12	$38.58
Permits (number)	127	43	173	2,435
Applications (number)	1,014	820	6,531	8,795

Table 2.—Mountain goat hunting permit values by combined herd unit at reported cost.

Combined herd unit	Average net WTP per permit	Net WTP + Resident fee[1]	Number of permits
4	$374	$445	2
9A-1	396	467	2
10-3	394	465	1
12	372	443	4
16	398	469	2
18	326	397	5
36A1-4	390	361	16
43 1-2	319	390	4
48 1-2	338	409	4
51	260	331	3

[1]*Resident fee = $71.*

Table 3.—Moose hunting permit values by herd unit at reported cost.

Combined herd unit	Average net WTP per permit	Net WTP + fee[1]	Number of permits
01 (1-4)	$111	$182	15
10	104	175	2
10A	108	179	2
12 (3-10)	110	181	31
15 (1-5)	109	180	19
16	111	182	4
16A	107	178	2
17 (1-2)	106	177	8
20 (1-2)	98	169	6
59	110	181	4
61 (1-3)	108	179	22
64	113	184	2
69 (1-2)	114	185	16
76 (1-6)	116	187	58

[1]*Fee = $71.*

mit.[4] Adding the license fee of $71 to the consumer surplus per permit yields a net economic value of $183.84 per permit. This translates to $31 per day. Depending on the number of hours hunted per day, the value per 12-hour Recreation Visitor Day would be between $40 and $50. Table 3 presents the average permit values associated with each moose hunting herd unit. These values do not include the license fee. These site-specific values (and the associated permit fee of $71) would often be more appropriate to use in National Forest or project level planning than the state average values.

The net present value to hunters of maintaining an area for moose hunting is $18,300 at 4%. This is the value to hunters flowing from use of the moose population for the brief hunting season and excludes observation-photographic values and existence values. Given the great public outcry over moose hunting in Maine (presumably by persons whose observer values and existence values were diminished by hunting of moose) one could expect these nonhunting values to easily be an order of magnitude larger than the hunting values.

Bighorn Sheep.—Using a standard cost per mile the estimated net willingness to pay for a bighorn sheep permit is $127.54 (table 1). With an average of 8.6 days hunted per permit,[4] this translates into a value of $14.83 per day. Probably a more accurate estimate of net willingness to pay is provided by rescaling the vertical axis of the demand curve using "reported cost." This yields a net willingness to pay of $239 per permit or $27.80 per day (table 1). The per day value is fairly low due to the substantial number of days hunted by each permittee. The 95% sensitivity interval is $204 to $278 per permit. When the hunting fee of $71 is added the net value or economic efficiency value of a permit is $310. Table 4 presents the site-specific average (and with a lottery, marginal) consumer surplus values for a permit. These numbers will often be more useful in National Forest and project level planning than the state average value.

Table 4.—Bighorn sheep hunting permit values by combined herd unit at reported cost.

Combined herd unit	Average net WTP per permit	Net WTP + Resident fee[1]	Number of permits
19	$246	$317	4
20	220	291	15
20A	234	305	15
21	223	294	5
26	230	301	15
27	249	320	38
28	236	307	17
41	244	315	2
42	238	309	9
50	241	312	7

[1]*Resident fee = $71.*

The net present value of bighorn sheep hunting in a typical unit offering five permits valued at $239 apiece is $29,875 (based on annual value of $1,195). Including the resident hunting fee as discussed above, yields a net present vlaue of $38,750 to hunters for maintaining existing areas for bighorn sheep hunting (and again assuming no real rise in relative value over time). A rough approximation of the observer option and existence values to big game hunters (again ignoring the existence and option values of other users) can be computed using the data of Brookshire et al. (1983). They estimate what potential Wyoming hunters would be willing to pay for the option to hunt or observe bighorn sheep in the future and their willingness to pay to know bighorn sheep exist. Using a survey of Wyoming hunters they calculate the annual observer option price of $34 (in 1982 dollars) per permit. For hunters willing to pay for preservation of bighorn sheep but who do not expect to see one in the wild, the annual existence value per permit is $11 (in 1982 dollars). Because these are values given by Wyoming big game hunters, they can at best be applied to Idaho big game hunters only. If we assume that the proportion of Idaho hunters falling into observer and existence categories is the same as in Wyoming, then 75% are potential observers and 25% receive existence values. The annual observer net willingness to pay for a typical bighorn sheep herd unit in Idaho is $216,325. (This figure is obtained by taking 75% of the Idaho big game hunters times the observer option price and then dividing by 30 bighorn sheep units). The annual existence net willingness to pay for a typical bighorn sheep herd unit is $23,191. (This figure is obtained by taking the remaining 25% of the Idaho big game hunters and multiplying by the mean existence value per permit and then dividing by 30 bighorn sheep units to get the value per unit). These calculations provide a measure of the average existence and observation values. Because these calculations provide the average willingness to pay for observer option value and existence value, they likely overstate the additional willingness to pay for the option of seeing one more bighorn sheep or knowing that one more bighorn sheep exists. Partly compensating for this upward bias in herd unit option prices and existence values, however, is the fact that observer and existence values for bighorn sheep in Idaho have been omitted for the nonhunting population in Idaho and other states.

While these observer option prices and existence values are at best rough approximations for Idaho bighorn sheep, they are likely accurate in their order of magnitude. These estimates do allow comparison of the hunter values to observe, and existence values for unique species such as bighorn sheep. The annual hunting values represent less than 1% of the annual viewer values and about 5% of the annual existence values of hunters. If available, the existence and viewer option prices to all users should be included when calculating the net present value of preserving an area for bighorn sheep. To be conservative in generalizing the Wyoming results, we will just include the viewer option price and existence values of hunters in Idaho in calculating the net present values of each herd unit. Summing the annual hunting values, observer option price and existence values for a typical herd unit to hunters only and then applying the 4% discount rate yields a net present value of about $6 million for each unit. This $6 million compares with $38,000 when only the hunting values are used. Accepting these approximations of option and existence values, the hunting values represent less than 1% of the total economic value of preserving these unique species.

Antelope Hunting.—At the standard cost per mile the state average net willingness to pay by antelope hunters is $59.21 per permit. This translates into a net willingness to pay of $31.16 per day as each permit involves slightly less than 2 days of hunting.[4] Adding the $31 tag fee results in a net value of $90 per permit or about $45 per day. Converting added miles to dollars using the reported cost associated with deer hunting ($0.183 per mile) yields a net willingness to pay of $73.31 per permit (table 1). Adding the license fee of $31 yields a value per permit of $104. This converts to a net value of $54 per day. The 95% sensitivity interval around the $73 permit value is $67 to $81. The figures for antelope are compared to other species in table 1. Table 5 presents the net willingness to pay values for each antelope hunting unit.

Table 5.—Antelope hunting benefits by herd unit at reported costs.

Combined herd unit	Average net WTP per permit	Net WTP + resident fee[1]	Number of permits
29 (1-6)	$71	$102	125
30	66	97	40
30A	69	100	100
36A1-2	61	92	50
37 (1-2)	67	98	175
37A	67	98	75
40	75	106	50
41	69	100	10
42 (1-2)	69	100	75
46	73	104	10
49	74	105	90
50 (1,2,3)	73	104	215
51 (1-4)	73	104	350
58 (1-2)	74	105	250
59 (1,2,3)	75	106	250
60 (1-2)	75	106	200
63 (1-2)	73	104	300
68	74	105	50

[1]*Resident fee = $31.*

The effect of including a substitute variable in the antelope demand equation was evaluated by comparing benefit estimates with and without a substitute variable. Converting added distance to dollars using standard cost per mile resulted in a net value of a permit of $59.21. This value reflects the presence of a substitute term. Estimating an equation identical to the antelope hunting demand curve except not including substitute yielded a consumer surplus value of $84.61 per permit at standard cost. This benefit estimate without a substitute term is about 40% higher than the estimate with substitutes. This reduction in value is often assumed to be the normal response to the inclusion of substitute sites. However, this reduction in benefits occurs primarily when the own price variable (here distance) and the omitted variable (here substitutes) are negatively correlated and the sign on substitutes is negative (Kmenta 1971). This is just one of two configurations for the relationship between substitutes and distance (Caulkins et al. 1985). If these two variables are positively correlated, the omission of substitutes would bias the benefit estimate downward. In the case of antelope hunting, the distance and substitute terms were negatively correlated. Thus, our estimate of net benefits was reduced when a substitute variable was added to the antelope hunting demand curve. What is even more striking is that the estimated number of applications from the equation without substitutes is larger than actual number of applications by a factor greater than 10. Apparently a large part of the misestimation of visits stemmed from omission of a substitute variable rather than heteroskedasticity.

The annual net willingness to pay from a typical area offering 90 antelope hunting permits is $6,598 and the net value (including fee) is $9,360 per year. To calculate present values this annual benefit stream is discounted at 4%, which yields a present value or worth for an average herd unit of $164,950. The present worth of the net economic value (including the license fee) is $234,000. Again it must be stressed that this is only the net willingness to pay of the hunters who get permits and assumes a zero value to hunters not getting a permit that year and to nonconsumptive users.

Interpretation of Results: Average Versus Marginal Values in the Case of Lottery Rationing

Both statewide and hunt unit average values have been presented. Each type of value is appropriate for a different decision context. If one is performing region-wide analysis, these state-wide numbers may be more useful than the site-specific numbers presented by species in tables 2, 3, 4, and 5. The hunt unit specific values may be more appropriate for valuation at the National Forest or project level than state average values. The numbers in these tables are site averages. These average values are also marginal values under the condition of non-price rationing such as a lottery (Mumy and Hanke 1975). Therefore, the analyst wishing to use these numbers can do so for analyzing both small changes involving a few permits or large changes involving elimination of big game hunting at the entire site. The reason that the average value equals the marginal under nonprice rationing is that without a pricing system (for example the limited hunt species lottery in Idaho) there is no way to insure that high valued hunters receive a permit before lower valued hunters. An additional permit offered could just as likely go to a low valued user before a high valued user. Thus the ordering of receipt of the good from high to low valued users implicit in the traditional demand curve is violated in a lottery situation. Therefore an additional permit does not necessarily go to the next highest valued user as it

would under pricing. This being the case, the value of additional permits (i.e., the marginal value) is calculated as an expected value of the lottery. This expected value of an additional permit turns out to be the average value of a permit.

These values are for the hunting activity and it would be incorrect to calculate a value per animal from them. The value per animal may be misleading because the animal provides other benefits beyond just hunting.

Conclusions

This study demonstrates that the Regional Travel Cost Method approach can be generalized to use data from permit applications to estimate the value of hunting "limited hunt" species such as bighorn sheep or mountain goat. Thus, the findings of Loomis (1983) for the single-site Travel Cost Method appear valid for the multi-site Regional Travel Cost Method as well. For some of the unique species, the net value of a hunting permit is quite large. Mountain goat hunting in particular had a permit value of nearly $400 and a per day value of nearly $100.

The study also demonstrates that the number of applications by hunters for a specific unit is sensitive to the success rate or quality of that unit. This is encouraging in that it shows the Travel Cost Method is sensitive enough to pick up subtle factors influencing hunter behavior.

The cost effectiveness of implementing the Travel Cost Method with existing data was encouraging. About eight weeks total was the time required for one economist to estimate benefits from raw data on a tape for mountain goat, bighorn sheep, and moose hunting. An additional week's time was required to estimate benefits for antelope hunting because of the need to estimate regressions and calculate benefits with a substitute term. While these are not extremely fast times, they are faster than those expended with the large-scale models utilized in the past. The lower costs are largely attributable to the use of sort-aggregate programs in SPSS and Fortran programs to substitute indexes and second-stage demand curves.

Lastly, the values per day derived should be helpful to USDA Forest Service and Bureau of Land Management analysts as they attempt to evaluate the economic benefits of managing these wildlife species. The values can also serve to inform decisionmakers of the loss in economic benefits from reduction in hunting opportunities for these species. While the values do not represent the total economic value of these wildlife species to all persons, the net present value of hunting in most herd units is in the thousands of dollars annually. This value needs to be compared with the net values of other conflicting activities to see if a resource management action provides a gain or a loss in economic benefits to hunters keeping in mind that hunting benefits may represent as little as 1% of the total economic benefits of these unique species in Idaho.

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Appendix

Average and Marginal Consumer Surplus – Conditions of Equality

The objective of the proof is to show that average benefits are equal to marginal benefits in relation to the per capita (stage I) demand curve. The means to accomplish this is to derive the mathematical expression for the benefits in each case and to show these are equal. The conditions under which this is true are:

1. Demand relationships between visits per capita and price (cost of travel) can be validly modeled with a semi-log functional form such as

$$\ln(q) = a - bp \qquad [A1]$$

or equivalently,

$$q = e^{a-bp} \qquad [A2]$$

where q is quantity, in this case, visits per capita
p is price, in this case, travel cost
a is the intercept parameter
b is the slope parameter

2. The only shifting variables allowed in the equation affect the intercept. No slope shifting variables are in the equation.
3. A slight relaxation of condition 2 occurs if there are slope shifting variables but they do not change from the "before" to the "after" states.
4. Each origin is a price taker in that people from that origin may visit the site as many times as they desire at their current travel cost. Therefore, the supply curve facing a given origin is horizontal. Due to differences in location from the site, each origin faces a different horizontal supply curve.

The "Before" State

Figure A–1 shows the overall scope of the changes considered in the proof. At equilibrium in state 1 (i.e., the "before" state) the demand curve has a quantity intercept of e^{a_1} when price is zero. As price increases, quantity decreases and asymptotically approaches zero for very large p. For a price of p_1, visits per capita to a site from a specific origin are q_1.

Total benefits per capita that accrue to the presence of the site, given all other existing sites, are represented by the shaded area labeled CS_1 (consumer surplus in state 1). This area is found by integrating under the demand curve and above the price line p_1.

Let a small segment of the area, dCS, be

$$dCS = q\,dp \qquad [A3]$$

as shown in figure A–1.
Then

$$CS = dCS = \int_{p_1}^{p} q\,dp \qquad [A4]$$

The limits of integration define the lower boundary of the CS area, the p_1 price line, and the upper boundary of the CS area, the point where p goes to infinity and q goes to zero. In spite of these extreme values, it turns out the CS area is finite.

Substitute for q from equation [A2] in the integral in equation [A4] giving

$$CS_1 = \int_{p_1}^{p} e^{a_1 - b_1 p} dp \qquad [A5]$$

where the subscript 1 denotes state one ("before"). Continuing with the integration gives

$$CS_1 = e^{a_1} \int_{p_1}^{p} e^{-b_1 p} dp = -\frac{1}{b_1} e^{a_1 - b_1 p} \Big|_{p_1}^{p} \qquad [A6]$$

Evaluating the expression in [A6] at the limits of integration gives

$$CS_1 = -\left(\frac{1}{b_1} - e^{a_1 - b_1 p}\right) - \left(-\frac{1}{b_1} e^{a_1 - b_1 p_1}\right) \qquad [A7]$$

$$CS_1 = \frac{1}{b_1}\left(e^{a_1 - b_1 p_1} - e^{a_1 - b_1 p}\right) \qquad [A8]$$

In order to include the entire area under the demand curve, let p (not p_1) become infinitely large, ($\rightarrow\infty$). For large p

$$e^{a_1 - b_1 p} = q \rightarrow 0 \qquad [A9]$$

so that the expression for CS in [A8] becomes

$$CS_1 = \frac{1}{b_1} e^{a_1 - b_1 p_1} = \frac{q_1}{b_1} \qquad [A10]$$

Average consumer surplus in state one per trip made (q_1) is

$$\overline{CS}_1 = \frac{CS_1}{q_1} = \frac{1}{b_1} e^{a_1 - b_1 p_1} \frac{1}{q_1} \qquad [A11]$$

But $\qquad e^{a_1 - b_1 p_1}$ is $q_1 \qquad$ [A12]

So $\qquad CS_1 = \dfrac{1}{b_1}$

Thus, average consumer surplus per trip in state one, the "before" state, is simply the inverse of the slope parameter from the demand equation, assuming the conditions previously stated are met.

The "After" State

Now, assume that managers of the recreational sites under consideration wish to increase the attractiveness of the specific site, for example, by increasing the number of animals or fish potentially harvestable. This new condition becomes the "after" state.

The new attractiveness at the site increases the intercept to e^{a_2}, but does not affect the slope coefficient b, as assumed, so $b_1 = b_2 = b$, (i.e., quality is an intercept shifter only). Using the result of the previous section, that, in general under the stated conditions,

$$CS = \frac{1}{b} e^{a-bp} = \frac{q}{b} \qquad [A13]$$

and placing the subscript (2) for the "after" state on the variables, total per capita consumer surplus for the "after" state is

$$CS_2 = \frac{1}{b_2} e^{a_2 - b_2 p} = \frac{q_2}{b_2} \quad \text{[A14]}$$

Note that "after" average CS is also $\frac{1}{b_2} = \frac{1}{b}$.

The total change in consumer surplus from the "before" to the "after" state is

$$\Delta\ CS = CS_2 - CS_1 \quad \text{[A15]}$$

$$\Delta\ CS = \frac{q_1}{b_2} - \frac{q_2}{b_1} \quad \text{[A16]}$$

But, as noted, $b_2 = b_1 = b$, so

$$\Delta\ CS = \frac{q_2 - q_1}{b} \quad \text{[A17]}$$

The marginal change per unit increase in trips is defined as

$$\frac{\Delta CS}{\Delta q} = \frac{\frac{q_2 - q_1}{b}}{q_2 - q_1} \quad \text{[A18]}$$

So

$$\frac{\Delta CS}{\Delta q} = \frac{1}{b} \quad \text{[A19]}$$

And since $b = b_1 = b_2$, combine the results of the derivation of "before" average consumer surplus and the derivation of the marginal consumer surplus caused by the change to the "after" state.

Thus,

$$\overline{CS}_1 = \frac{1}{b} = \frac{\Delta CS}{\Delta q} = CS_{marg} = \overline{CS}_2 \quad \text{[A20]}$$

and the proof is complete given that the preceding conditions are met.

Note in the proof that the relationship in equation [A20] does not depend on the price level, even though figure 6 shows price unchanging. Neither do the key equations for "before" and "after" consumer surplus, equation [A10] and [A14], respectively. Under the stated conditions, there may or may not be a price change along with the demand curve shift. Regardless, it does not affect the equality between the "before" average consumer surplus and the "before" - to - "after" marginal change in consumer surplus. Moreover, the price may change in either direction without affecting the results.

Loomis, John B., Dennis M. Donnelly, Cindy F. Sorg, and Lloyd Oldenburg. 1985. The net economic value of hunting unique species in Idaho: Bighorn sheep, mountain goat, moose and antelope. USDA Forest Service Resource Bulletin RM-10, 16 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

The net economic value of hunting unique species in Idaho was estimated using the Travel Cost Method. The net willingness to pay per hunting permit was $239 for bighorn sheep, $360 for mountain goat, $113 for moose, and $73 for antelope.

Keywords: Valuation, big game, Idaho, economic values

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Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

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